Conceptual Landfill Design for the Urban Community of Meknes Morocco

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By

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General

The preliminary Assessment of Solid Waste Management Systems, completed in July 1995, identified significant problems in the subject cities of Meknes, Azrou and Sefrou. These problems included technical issues dealing with collection and disposal as well as institutional and financial problems associated with improved waste management services. Action plans were prepared for each city that summarized the technical assistance team's recommendations. Of all the problems encountered in the three cities, the Meknes landfill was considered the most severe. The Meknes action plan recommended an interim program for landfill closure and siting of a new long term landfill. The City has responded to these recommendations in a timely manner and has located an interim landfill site and completed a review of potential new sites. This report consists of a review and comments regarding the interim plan and a conceptual design and cost estimate for the proposed new long term landfill.

Project Meeting

In order to assist the project team to determine the scope of work to be performed under this phase of the project, a meeting was held with the Urban Community and the four individual communes. The meeting was hosted by the mayor of the Urban Community and was attended by political as well as technical representatives of the four communes. Problems discussed were similar to those addressed during the preliminary assessment. Although many issues were raised about collection problems, public education and awareness, and institutional/financial matters, it was agreed by all those present that the limited scope of this phase of the project should concentrate on the technical issues of the interim landfill plan and the location of the new long term landfill.

Interim Plan

The interim landfill plan proposed by the City will provide an estimated 12 months of additional landfill capacity, while providing sufficient final cover soil for both the existing and interim areas. The success of this plan will depend on efficient excavation of the area prior to filling and control of the site to avoid conflicts with existing landfill operations, which must continue during the excavation phase. During and after the 12 month interim period, the site should be monitored regularly to prevent a return of clandestine dumping.

New Landfill Site

The City has done an excellent job of applying the landfill criteria presented in the Preliminary Assessment Report and evaluating potential sites. This process has located a suitable landfill site with excellent hydrogeologic features, a capacity in excess of 40 years and minimal environmental and socio-economic impacts. The site consists of 178 hectares of public land located approximately 8 kilometers north of the City. A small village located on one corner of the site is the only residential development nearby. This village will be visually screened from the actual landfill, which will be located in a valley approximately 800 meters from the village.

A composite topographic map, which was prepared for this report, formed the basis of a conceptual design of the proposed landfill. The excavation plan and final contour map that were prepared determined the maximum potential capacity of the site at 9.8 million cubic meters for a life span of 43 years. A second area on the same land parcel could also be developed in the future, which could extend the landfill's life to over 70 years. These estimates are based on maximizing the site capacity through excavation and phased construction.

Due to the deep clay soils, environmental concerns from water pollution are minimal. Leachate estimates, using computer models, indicate two to four centimeters of leachate generation per year. This amount can easily be collected and managed on-site.

Cost Estimates

Preliminary cost estimates were prepared based on the conceptual design and operating assumptions. Total capital costs, including project development, initial construction and equipment costs are estimated at 6.4 million Dirham (DH). Total first year costs, including operation and maintenance and annualized capital costs, are estimated to be 1,862,000 DH, or approximately 25.50 DH per tonne of waste.

Development Issues

Although City officials are anxious to proceed with the new landfill, they face a significant constraint in their inability to increase local revenues to pay for the new landfill. Any new tariffs or increases in existing taxes must be approved by the national government, which involves a time consuming process. A World Bank project in the Sebou River Valley has proposed a new, separate tariff for waste management that may offer a solution in the near future. Privatization of the landfill operations may offer some advantages to public operation and should be evaluated further.

Recycling Center

The transfer of operations to the new landfill site offers a unique opportunity to resolve some of the many problems that have affected the existing landfill operation. It is proposed that the former compost facility should be converted to a recycling and materials processing center. This would remove many of the scavenging and recycling operations from the landfill and place them in a more controlled and manageable location.

Action Plan

The various recommendations included in the report are summarized as follows:

1. Proceed immediately with the interim landfill plan, which will close the existing landfill and provide an additional 12 months of landfill capacity.

2. Perform a topographical and boundary survey of the proposed site to confirm physical features and provide a more accurate topographic base map for final design.

3. Perform the hydrogeological investigations outlined in Attachment A.

4. Consult with the appropriate national officials to evaluate cost recovery methods, new tariffs, or other financial/institutional arrangements in order to finance operation of the new, improved waste management procedures.

5. Consult with applicable donor agencies on the availability of funding for additional investigations, final design and landfill construction.

6. Consult with local officials from the four communes and establish a landfill development strategy that includes private as well as public options.

7. Evaluate the conversion of the former compost facility to a recycling and materials processing facility.

Conceptual Landfill Design for the Urban Community of Meknes

1 INTRODUCTION

1.1 Background

The United States Agency for International Development (USAID) is assisting Moroccan municipalities through the Urban Services Project (U&ES). The cities of Meknes, Azrou and Sefrou were the subject of a Preliminary Assessment of Solid Waste Systems, completed in July 1995. This preliminary report, which addressed the technical issues of waste generation, collection and disposal in the three subject cities, presented action plans to address the many problems found in each city. Although problems exist in all three of the subject cities, the problems in Meknes were judged more severe and in urgent need of action, particularly the current situation of the existing landfill and the need to look for a new long term solution.

The Executive Summary of the July 1995 Assessment presented an action plan for each municipality. Closure of the existing landfill and location of a new long term site were assigned a high priority in the Meknes Action Plan.

1.2 Goals and Objectives

The City of Meknes has responded to the recommendations contained in the initial assessment in a timely manner. They have prepared an interim landfill plan, as recommended in the assessment report, and have performed an evaluation of available public lands for the siting of a new long term landfill. The primary goals and objectives of this final phase of the project are to assist the City of Meknes in implementing both its interim and long term landfill plans. This has been accomplished through an additional site visit to Meknes, where the ICMA consultant reviewed the interim plan with city officials and made recommendations for its implementation.

In addition to offering guidance on the interim landfill plan, the site visit included an initial assessment of the site selected by the City as the most likely long term landfill site. This assessment included a conceptual design of the proposed landfill and conceptual cost estimates.

2 INTERIM PLAN

2.1 General

As stated in the initial assessment report, the interim landfill proposal is intended to provide landfill capacity for an interim period while a new long term site is developed and to provide cover soil for the existing landfill. The City evaluated two potential locations for the interim landfill site. Proposition 1 is a privately owned site located below and to the northwest of the existing landfill, which would require a new access road. Proposition 2 is on public land adjacent and southeast of the existing landfill. Based on increased costs for acquiring public land and the new access road, the City selected Proposition 2 for implementation. The location of the proposed interim landfill is shown on Figure 1.

2.2 Capacity

According to the City's calculations, the area of the existing landfill to be covered with soil is 20,000 square meters, and the proposed interim area consists of 18,000 square meters, for a total of 38,000 square meters to be covered. At a final cover soil depth of .5 meter, the volume of soil required will be 19,000 cubic meters. Due to the irregular topography and the need for daily cover during the interim operating period, the team recommends that at least 25,000 cubic meters of soil be excavated from the interim area.

The Waste Generation Data Base, prepared during the preliminary assessment, estimates that the annual landfill volume required is 144,300 cubic meters. Dividing this capacity by the 18,000 square meter size of the interim area produces a waste depth of approximately 8 meters. Therefore, in order to obtain a 12 month interim period, the area must be excavated so that an average final waste depth of 8 meters will be obtained.

2.3 Excavation

The elevation of the interim area slopes to the north at approximately 10 percent, from 480 to 450 meters (see Figure 1). Assuming that the final elevation of the interim area will be equal to that of the existing landfill, which is approximately 460, the area should be excavated to an elevation of 450 meters in order to obtain an 8 to 10 meter waste depth for 12 months of capacity.

The excavation of the area will require a well organized plan to allow the excavation to proceed without interrupting the operation of the landfill, which must continue. The largest constraint to this plan is the narrow access road to the existing landfill. During the initial excavation of the interim area, this road must be widened to accommodate both the trucks hauling cover soil from the interim area to the existing landfill and the trucks delivering waste to the existing landfill.

In addition to covering the existing landfill, approximately 50 percent of the excavated soil, or 12,500 cubic meters, will need to be stockpiled on the existing landfill for later covering of the interim landfill once it is completed in approximately 12 months. The location of this stockpile should be determined in advance of the interim excavation. When the interim area is fully excavated, and all excavated soil has either been used to cover the existing landfill or stockpiled, then the existing landfill can be officially closed and all waste diverted to the interim area.

2.4 Cover Existing Landfill

The side slopes of the existing landfill are too steep to be effectively covered with soil; therefore, the previously mentioned calculations apply only to covering the upper, flat areas of the existing landfill. Although it would be possible to dump soil on the steep slopes from above, it

Lay in Figure 1

would not be possible to adequately compact this soil, and it would quickly erode due to wind and rainfall. Methods of covering steep slopes using composite soil matting and synthetic materials are very expensive and inappropriate for arid and semi-arid climates.

Prior to placing the cover soil, the existing landfill should be graded where required to remove irregular formations and eliminate low spots. All areas should be graded to drain to the edges of the landfill. In general, a slope of 2 to 4 percent will ensure adequate drainage. Cover soil should be applied and compacted in two layers 25 centimeters thick. Cover soil compaction is essential to obtaining the desired low permeability and resistance to wind and water erosion. Depending on the soil type and weather conditions, the excavated soil may be too dry to compact properly. In this case the soil must be sprayed with water to increase its moisture content. Although the optimum moisture content will vary with the soil, a moisture content of 30 to 40 percent should ensure adequate compaction.

2.5 Fires and Methane Gas Generation

The existing landfill has burned for most of its active life. Landfill fires have many sources, including fires started by scavengers for cooking or to keep warm and the burning of confidential documents by government officials. Hot coals brought in with the waste are also a common source of landfill fires. Once landfill fires start they are often difficult to extinguish because they can burn deep within the landfill and can burn slowly for many years. The placement of cover soil will help to extinguish the fires by cutting off the supply of oxygen. Water pumped into the landfill can also help extinguish landfill fires. However, even with the above efforts, the existing landfill fires may continue smoldering for several years after closure.

Landfill fires are the result of burning materials in the waste such as plastic, paper, wood and other organic matter—not methane gas. Methane gas is very explosive and will not burn slowly as a landfill fire burns. If sufficient methane gas accumulates in a confined space above its combustion limit of approximately 5 percent, it will explode. Due to the low density and high permeability of waste in a landfill, methane gas usually escapes to the atmosphere, and gas build-up within the landfill seldom occurs. Explosions in landfills due to methane gas are rare or nonexistent.

The potential problem occurs when the landfill is closed and covered with a low permeability soil or plastic membrane that blocks the escape of methane gas to the atmosphere. Under these conditions, methane gas can build up under the cover soil and migrate off-site. In some instances, landfill gas has leaked into adjacent homes, causing explosions. Since these conditions may exist in the Meknes landfill, methane vents should be installed in both the existing and interim landfills, along with the final cover soil. Methane vents consist of a perforated pipe, placed in the completed landfill, that extends through the cover soil and is open to the atmosphere.

The number of vents and their locations are based on the shape and physical configuration of the completed landfill. Since the steep side slopes of the existing landfill will not be covered, methane gas will naturally escape to the atmosphere from most of the existing landfill. The interim landfill area and portions of the adjacent existing landfill will be confined and properly covered and should therefore be vented. Recommended locations and spacing of methane vents are shown on Figure 2.

2.6 Fill Procedures

The placement of waste in the new interim area should follow the procedures outlined in Section 1.4.6 of the initial assessment report. In particular, the procedures outlined in Figure 1 for placement, compaction and covering of waste should be followed. Figure 5, found in Section 2.7 of the assessment report, shows the various stages of excavation and cell construction that should be applied to the interim landfill area.

2.7 Site Clean-up

During the 12 month interim period, the City should remove the accumulation of waste that has been dumped along the access road. This clandestine activity must be stopped and the area kept clean. All waste removed from the area should be placed in the interim landfill area and covered.

A very important part of the clean-up activity will involve clearing the area occupied by the scavengers and recyclers. Since the landfill will be closed after the interim landfill is full, these people should be relocated to another location. One of the major objectives in locating the new landfill is to control access to the site and unauthorized scavenging and grazing of livestock on the landfill. A proposal is presented later in this report to utilize the former compost facility as a recycling and materials processing facility, in an effort to keep these activities within the City and not at the new landfill site.

2.8 Site Monitoring

The interim period may be a confusing time for residents and city workers who use the landfill. In order to prevent continued clandestine dumping along the access road, additional monitors should be assigned to the site to control truck traffic and dumping. A supervised gate should be installed at the entrance to the access road to record the delivery of all waste. Upon entering the site, each waste hauler should be given clear instructions as to where to place the waste.

This gate house should be maintained for at least three months after the new landfill begins operation to ensure that clandestine dumping does not return to the former landfill site.

3 NEW LANDFILL SITE

3.1 General

The assessment report outlined the primary siting criteria for locating a new landfill site. A preliminary review of hydrogeologic features identified a large area of favorable clay soil

Lay in Figure 2

conditions to the north of the City. Although a general inspection of this area was performed during the assessment report, specific sites were not identified. After the completion of the assessment report, the City reviewed several potential sites that are either public lands or available for purchase. These sites were reviewed and eventually narrowed down to one favorable site, which is the subject of this conceptual design report.

3.2 Location

The location of the proposed new landfill is shown on Figure 3, Location Map. This figure shows the proposed site located approximately 8 kilometers north of the City center along the road to Tanger. The site is situated well within the clay area identified during the preliminary hydrogeologic review of the assessment report and is currently in agricultural use. Figure 4, Site Map, is a composite map prepared from the topographic map in Figure 3, with the addition of approximate property boundaries from a map provided by the City. Several other physical features that will impact the proposed landfill have been added to the map.

A small village is located northwest of the site, at the intersection with the road to Volubilis and Moulay Idriss. Based on the composite map, it appears that the village is within the 178 hectare site, which is reported to be public land. Since this village may exist on public lands, without permission, its legal status is in question, and further investigation should be performed.

Another important physical feature of the site is a high voltage power line, which bisects the site. The power line is not included on either of the two maps used to create the composite site map—its location is based on visual observations made during the site visit. Since the location of the high voltage power line will significantly impact the landfill design, its actual location along with all property boundaries should be determined by a field survey. Above ground structures are not permitted within 25 meters of the power line.

3.3 Siting Criteria

3.3.1 General

The assessment report included a list of criteria to be used in siting a landfill. These criteria were established to limit both environmental and social/economic impacts to residents or other land uses in the area of the landfill. The application of each criterion to the proposed landfill is presented in the following sections.

3.3.2 Distance to Surface Waters

The nearest flowing river is located approximately 900 meters west of the proposed landfill. The assessment report recommended a distance of at least 100 meters as adequate separation distance. The 900 meters should provide more than adequate protection from pollution in the unlikely event of an overland flow of leachate.

Lay in Figure 3

Lay in Figure 4

The landfill site is located in a gentle valley. The topographic map shows a dashed line in the valley, indicating a potential drainage path, but no evidence of seasonal flow, erosion or a stream channel were found during the site inspection. An 80 cm concrete pipe crosses the main road at the intersection with the road to Volubilis and is the apparent drainage outlet for the site. No evidence of recent flow was observed at either the entrance or exit to this pipe.

It can be assumed that in heavy rainfalls, some overland drainage flow may exist in the valley to be used for the proposed landfill. Since this flow may contain leachate generated by the landfill, the landfill design should include a stormwater detention pond to capture all drainage coming from the landfill site. This basin should be designed to hold the maximum anticipated storm without discharge. Retained water should be permitted to evaporate or infiltrate into the soil.

3.3.3 Distance to a Well or Potable Water Intake

Due to the deep clay soils, there are no known water wells in the area. Water for the village and a restaurant at the road intersection obtain their water from a pipeline running from Meknes to Moulay Idriss. Therefore, there will be no impacts to potable water supplies.

3.3.4 Wind

Wind can be a problem at landfills due to dust, windblown debris, odors and smoke. Although proper operation will reduce impacts due to wind, some impacts can be expected at any landfill. Data on prevailing wind strength and direction were gathered during the preliminary assessment and are presented in Figure 5, Wind Data. The wind data indicate that the prevailing wind during the summer and fall months is from the southeast to the northwest. During the winter and spring, the prevailing wind is from the east to the west. Since the village at the road intersection is northwest of the proposed landfill site, some impacts due to wind can be expected during the summer and fall. Since the proposed landfill will be located in a valley, and the village is located approximately 800 meters from the landfill, these impacts should be minimal.

3.3.5 Distance to Residences

The assessment report recommended a distance of 300 to 1,000 meters as an appropriate separation distance from residences. This recommendation is based primarily on visible impacts, noise and the wind impacts noted above. The village at the roadway intersection is the only residential development near the landfill and, as stated above, is 800 meters from the site. Landfill operation will be in a valley and will not be visible from the village. Noise is also expected to be minimal due to the 800 meter distance and location in a valley.

3.3.6 Distance to Public Facilities, Sensitive Environments or Archeological/Historical Sites

There are no public facilities (schools, hospitals, mosques, etc.) near the landfill, nor any known environmentally sensitive, archeological or historic sites, on the proposed landfill site.

Lay in Figure 5

3.3.7 Distance from the Urban Center

The proposed landfill is at a distance of approximately 8 kilometers from the urban center of Meknes. This distance is well within the 5 to 10 kilometer distance recommended in the assessment report. All collection vehicles operating in Meknes should be able to access the proposed landfill without the need of a transfer station.

3.4 Hydrogeology

The data that were obtained and reviewed during the assessment report for Meknes included a hydrogeologic map of the Meknes-Fez Plain, prepared in 1967. This map identified the major geologic formations in and around Meknes. In general, the soils to the south, east and west of Meknes are more porous and have relatively good groundwater quality as evidenced by the many well locations shown on the map. The area north of Meknes is shown as an area of deep blue clay, without significant groundwater resources. A portion of this map was included in the assessment report as a guide to the City in identifying potential landfill sites and is also included in this report as Figure 6. Both the existing and proposed landfill sites are indicated on Figure 6. The approximate boundaries of the clay formation are also shown on Figure 3, Location Map.

During the assessment report, the inspection team visited two brick quarries, located north of Meknes and in the same clay formation as the proposed landfill. The quarries were approximately 3 to 4 kilometers south of the proposed landfill site. These quarries were 50 to 75 meters in depth and were dry. The high quality clay is being used to manufacture bricks and building tiles. If these conditions are typical of the remainder of the clay formation, the hydrogeologic conditions at the proposed site are excellent for the location of a landfill.

Although the general hydrogeology of the area indicates excellent conditions for locating a landfill, site specific information will be required before proceeding with final designs. As a minimum, test borings should be performed and test pits should be dug to confirm subsurface conditions. A proposed scope of work for site specific hydrogeologic investigations is included in this report as Attachment A.

3.5 Access/Traffic Impacts

The proposed landfill site is located along the major north-south highway to Tanger, which is more than adequate to handle the increased truck traffic between Meknes and the proposed landfill site. However, traffic within the four communes of Meknes was identified during previous discussions as an issue that may require further evaluation.

The existing landfill is located in the northern commune of Hamria. Existing traffic, accessing the landfill from the three other communes, currently travels through Hamria, with significant impacts to the local community. Although the proposed landfill will permit the re-routing of some of this traffic, the majority of the trucks must still pass through Hamria to get on the Tanger road, heading north to the landfill. Expected growth in the southern portions of the City will further increase truck traffic through Hamria. The City is aware of these potential problems and has

Lay in Figure 6

included long term plans to improve the major north-south traffic access, but due to limited resources, the implementation of these measures is unknown. The final design of the proposed landfill or environmental studies should include an assessment of traffic impacts within the four communes of Meknes.

4 CONCEPTUAL DESIGN

4.1 General

The following conceptual design is intended to provide the City of Meknes and other decision makers with adequate information in order to proceed with the project's development and begin to understand its economic, social and environmental impacts. It is based on preliminary information and many assumptions that must be confirmed before moving forward with final design and project financing. In particular, the conceptual design has been based on a composite map, including a small scale 10 meter contour map. Prior to final design the site must be surveyed to confirm the location of physical features and to prepare a more accurate contour map with 1 or 2 meter contours. In addition to the field survey, the hydrogeological features must be confirmed through the investigations summarized in Attachment A.

The power line bisects the site into two potential landfill sites. Although both sites are gently rolling valleys, the valley to the south of the power line is larger and more defined, requires less excavation and will present fewer impacts to the general public and the environment. The southern valley will therefore be the focus of this conceptual design. The northern valley may be developed in the future and may be needed for cover soil in the final phases of the south valley landfill.

4.2 Leachate Generation

Leachate is a liquid pollutant produced by all landfills. The amount of leachate produced, its strength and its composition depend on many variables, including rainfall and the composition of the waste being placed in the landfill. The control of leachate generation and management of leachate are major design aspects of every landfill that affect both construction and operation.

At this point in the conceptual design it is appropriate to estimate the amount of leachate that will be produced by the proposed landfill. This estimate is based in large part on climatological data but also requires several assumptions regarding waste composition and operating procedures. The United States Environmental Protection Agency has developed a computer model known as the HELP model to estimate leachate generation given the major variables that affect leachate generation. Although this model has been prepared based on climatological and waste composition data typically found in the United States, the variables can be adjusted to approximate conditions found in Morocco.

In applying the HELP model to Morocco the team used conditions found in the State of Texas in the United States as the closest conditions to those found in Morocco. The results are assumed to be conservative because Morocco is somewhat hotter and drier than Texas.

The team reviewed and summarized rainfall data for Meknes for the period 1986–90, with rainfall averaging 577 millimeters over that four year period. Assumptions were made regarding waste permeability, moisture content and cover soil based on observations made during site visits and previous documentation.

Results of several computer runs indicate that of the total rainfall of 577 mm (57.7 cm) only 2 to 4 centimeters per year actually percolates through the landfill as leachate. Considering the differences in the computer inputs and actual conditions in Morocco, it is conceivable that with proper operation, actual leachate production could approach zero.

The results of the computer simulation point out an important aspect of landfill operation. Approximately 70 to 80 percent of rainfall that falls on the landfill is absorbed and then evaporates or is removed by plant growth within the cover soil. This points to the importance of consistently applying daily and intermediate cover, especially during and prior to the wet season.

4.3 Site Access

Site access has been a major problem at the existing site. The existing access road is built nearly entirely on landfilled waste, and during heavy rain it becomes soft and muddy and is nearly impassable. Waste has been dumped along its entire length, compounding the problem by preventing rainwater from running off.

Due to the favorable topographic features of the proposed site, it is recommended to construct the landfill 500 to 600 meters northeast of the Tanger road in the gently sloping valley south of the power line. This will require an access road of approximately 800 meters to reach the first phase of the site. An additional 1,000 meters of access road will be eventually be necessary to access later phases of the landfill over its estimated life of more than 40 years.

As shown on the Site Map (Figure 4), the high voltage power line is located along the north side of the valley mentioned above. Since permanent above ground structures are prohibited within 25 meters of the power line, the path of the power line is an excellent location for the landfill access road. This will ensure that the road will not be built on landfilled waste.

The recommended alignment of the access road is shown on Figure 7, Excavation Plan. The road begins at the second turn after the railroad bridge on the Tanger road. As the main road turns to the west, the access road continues straight. A gate house should be located near the beginning of the road to monitor all waste deliveries and secure the site when it is closed. At least 50 meters of the access road near the gate house should be graded at 0 percent to allow for the future installation of a weighbridge, should it become necessary. Final design of the access road will address cut and fill requirements and design grades.

Lay in Figure 7

4.4 Excavation Plan

In order to estimate the total capacity of the site, and to determine the availability of cover soil, a final excavation plan has been prepared. Although the team does not anticipate or recommend full excavation of the site during the initial construction phase, the plan will assist in the conceptual design of construction phases and excavation of cover soil.

The excavation plan, shown in Figure 7, follows the basic grade of the valley, with most of the excavation occurring along the edges of the valley, increasing side slopes to a 1:4 slope. The overall objective of the excavation is to increase the site capacity and provide cover soil for daily operations. The final design will balance the excavation to provide cover soil equal to approximately 10 percent of the waste volume placed in the lower level of the landfill. Daily cover soil for the upper levels, and final cover soil, will be excavated from the area north of the power line, in preparation for the next landfill.

4.5 Final Contours - Closure Plan

A final contour plan has also been prepared as a necessary step to estimating site capacity and a guide for final design and overall site development. The final contour map will also assist in the evaluation of social and economic impacts of the completed site. A maximum elevation has been assumed at 360 meters. The visibility impacts of this landfill height should be evaluated during the final design. Finished side slopes are shown at 1:4.

Cover soil for later phases of the landfill and final cover will be excavated from the area north of the power lines. The contour lines shown on Figure 8 for the north area are final excavation limits similar to those shown on Figure 7 and may not reflect conditions at the time of closing the southern site.

4.6 Environmental Concerns

The fate of leachate produced in the landfill will depend on the characteristics of the base soil beneath the landfill. If the permeability of the soil is 1×10^{-7} cm/sec or greater, the 2 to 4 cm per year of leachate, estimated by the HELP model, will seep into the soil. Since groundwater is assumed to be at a very great depth, this leachate will have no adverse environmental impacts.

If, however, the base permeability is less than 1×10^{-8} cm/sec, as the team anticipates, then the soil will act as an impermeable liner and leachate may run out of the landfill and into the evaporation basin where it will be permitted to evaporate. The final design of the evaporation basin must incorporate both surface drainage and estimated leachate flow in its capacity design to prevent any release of flow.

The possibility of landfill fires is also a significant environmental concern, especially since there are residential areas downwind of the site. Considering the increasing amount of plastics within the waste, the burning waste has a high potential for producing toxic gases, causing both short and long term health impacts. The potential of landfill fires will be minimized by restricting

Lay in Figure 8

scavengers' access to the landfill and by inspecting each load of waste as it is dumped, especially during the winter months. Daily application of cover soil and construction of waste cells will also limit the impact of landfill fires. If landfill fires start, they should be extinguished as soon as possible with additional cover soil or water.

4.7 Construction Sequence

To maximize the potential capacity of the site and avoid unnecessary site development costs, the site should be developed in phases. The conceptual phased development sequence is shown on Figure 9. For the purposes of this conceptual report the team has assumed that the landfill will be constructed in three levels, each level being 10 meters in elevation. The selection of the phase size and depth has been assumed for presentation purposes only; final phasing will be a function of the final design.

Level 1 is divided into ten phases measuring 200 x 250 meters, for a volume of 500,000 M^3 per phase. Each phase will have a life of approximately three to five years. The first phase will be located at the lower end of the southern valley, adjacent to the power line. As phase 1 is being filled, cover soil will be excavated from phase 2. When phase 1 is completed, phase 2 should be fully excavated and ready to receive waste. The sequence is then repeated: as phase 2 is filled, cover soil will be provided by excavating for phase 3.

After level 1 is completed, probably in about 25 years, the sequence will return to the lower end of the valley, but since the excavation of the south site will have been completed, excavation of cover soil will begin in the northern site.

4.8 Capacity

The capacity of the landfill has been estimated by comparing the excavation plan and final contour plan using the end area method of calculating volume. This calculation produced a volume of 9.8 million cubic meters. This volume was then compared to the waste generation data base prepared in the preliminary assessment, resulting in a lifetime capacity of 43 years. The data base assumes a 2 percent population growth and a 10 percent cover soil factor. It also assumes that all waste generated, less recycling, is taken to the landfill. An extended version of the waste generation data base is included as Attachment B.

Although a conceptual design was not performed for the northern site, a rough estimate based on a comparison of areas indicates that if this site were developed, it could add another 30 years to the overall site life. This would give the landfill a total lifetime capacity in excess of 70 years.

4.9 Equipment

The proper operation of the landfill will rely on the operation and maintenance of large earthmoving equipment. The selection of this equipment will depend on the amount of waste being received and the characteristics of the cover soil. The following major equipment is recommended:

Lay in Figure 9

Landfill Compactor: Many heavy equipment manufacturers build specialty machines for spreading and compacting waste and cover soil for landfills. These machines are equipped with large steel wheels designed to achieve maximum compaction. One landfill compactor is recommended for initial landfill operations.

Excavator: A track mounted loader/excavator is recommended for excavating and loading cover soil. Based on preliminary investigations, the soil may be a heavy clay soil requiring a track mounted machine. A rubber tired loader will most likely not be adequate for this purpose. Depending on the nature of the cover soil and difficulty of excavation, this equipment may not be needed full time at the landfill and could be used for other public works projects.

Dump Truck: A dump truck will be needed to transport cover soil from the cover excavation site to the landfill. This equipment may also not be needed full time and could be used on other public works projects.

Water Tanker: The water tanker will serve several purposes. It is anticipated that the cover soil may be too dry upon excavation to be properly compacted. The water tanker will be used to wet the cover soil in order to achieve adequate compaction. The tanker can also be used to wet the access road to control dust and could also be used to extinguish landfill fires.

In addition to the above equipment, the landfill operator should construct an equipment depot for servicing and maintaining the equipment. The depot should be equipped with diesel oil facilities, repair shop for minor repairs and routine servicing, locker and bathroom facilities for landfill workers and an office for the site manager.

5 COST ESTIMATES

5.1 General

The cost estimates presented in Table 1 are based on the conceptual design and assumptions made regarding operation and maintenance. These estimates are suitable for planning purposes and preliminary financing but should be revised and updated subsequent to final design. The estimates also assume that the facility is operated by the Urban Community.

Some savings may result from contracting some of the operational functions to the private sector. For instance, excavation and stockpiling of cover soil could be contracted to the private sector, thus saving the cost of purchasing the excavator and dump truck. This option should be evaluated further after the final design has prepared a more accurate estimate of excavation and cover soil requirements.

TABLE 1

COST ESTIMATE

Capital Costs

Project Development Costs (in DH)

Survey, Investigations	50,000
Engineering	200,000
Legal & Administration	20,000
Subtotal Development Costs	270,000

Initial Construction Costs

Access Road 800 M @ 750 DH/meter	600,000
Gate House & Gate	40,000
Maintenance Depot	200,000
Utilities, water, power, telephone	90,000
Phase 1 Excavation	800,000
Evaporation Basin	80,000
Monitoring Wells	50,000
Contingencies @ 10%	200,000
Subtotal Construction Costs	2,230,000
TOTAL CAPITAL COSTS	2,500,000
Annual Cost 15 yrs @ 12%	367,000

Equipment Costs

Landfill Compactor	1,800,000
Excavator	1,200,000
Dump Truck	500,000
Water Tanker	400,000
TOTAL EQUIPMENT COSTS	3,900,000
Annual Cost 8 yrs @ 12%	785,000

Operation & Maintenance Costs

Labor:	6 Common Labor @ 24,000 DH/year	144,000
	3 Operators @ 36,000 DH/year	108,000
	1 Mechanic @ 36,000	36,000
	1 Site Manager @ 42,000 DH/year	42,000
	Subtotal Labor	330,000
Equipment Operation & Maintenance		200,000
Utilities		50,000
Environmental Testing		20,000
Administration & Overhead		50,000
Contingencies @ 10%		60,000
TOTAL OPERATION AND MAINTENANCE COSTS		710,000
TOTAL ANNUAL COSTS		1,862,000
COST PER TONNE @ 73,000 tonnes/year		25.53
COST PER TONNE IN U.S.$ @ 8.40 DH/$		$3.03

5.2 Capital Costs

Capital cost estimates include project development costs and initial construction costs. Project development costs—for a site survey, engineering and legal/administration—total 270,000 DH. Additional project development costs could include more detailed environmental studies if required.

Initial construction costs are based on the conceptual design and the phased construction sequence as presented in Section 4.7. The construction sequence assumes that some excavation is required prior to beginning the first phase, but that all excavation and access road extensions thereafter will be part of daily operations using on-site staff and equipment. These costs could change significantly after the final design, especially if more or less excavation is required. The access road, maintenance depot and initial excavation are the largest capital cost items. A 10 percent contingencies amount has been added for miscellaneous items.

Total capital costs are estimated at 2,500,000 DH. Although there are several potential development options for financing capital costs, the team has assumed in the conceptual cost estimate that the capital costs are financed over 15 years at an interest rate of 12 percent. The annual cost of capital expenses is calculated at 367,000 DH per year.

5.3 Equipment Costs

Equipment costs are estimated to be significantly greater than capital costs at 3,900,000 DH. As stated above, the estimate assumes public operation, with all site work after the initial phase of construction to be performed by on-site staff and equipment. It is possible that equipment costs could be reduced by contracting out the excavation and stockpiling of cover soil, but insufficient design detail exists at this stage to make such a comparison. Annualized equipment costs of 785,000 DH have been calculated, assuming an 8 year repayment period at 12 percent interest.

5.4 Operation and Maintenance Costs

Labor costs, found in Table 1 include taxes and benefits to workers. The six laborers assume three gatekeepers and three general laborers for traffic direction, security and waste inspection. It is recommended that the gate house be staffed full time, 24 hours per day. Three operators and one mechanic are assumed for efficient equipment operation and maintenance. Total labor costs are estimated at 330,000 DH per year.

At this point in the conceptual development, equipment operation and maintenance costs are estimated at 5 percent of capital costs, or 200,000 DH. These costs include fuel, tires, routine maintenance and spare parts.

Total operation and maintenance costs are estimated at 710,000 DH per year.

5.5 Total Annual Costs

As shown on Table 1, total annual costs are estimated at 1,862,000 DH. The cost per tonne of waste landfilled is calculated based on an average of 200 tonnes per day, 365 days per year, for a total annual tonnage of 73,000. This equates to a cost per tonne of 25.53 DH. Converting to U.S. dollars for comparison, at 8.40 DH per dollar, equals $3.03 per tonne.

6 DEVELOPMENT ISSUES

6.1 General

Current costs for public services such as solid waste management are financed through an Urban Services Tax. This tax is based on real estate value (rental value) and is fixed by the national government. The tax revenue is shared equally between the individual communes (50 percent) and the central Urban Community (50 percent) and is often absorbed into the general fund of each commune. At the present time this tax is fixed at 10 percent and is not considered adequate to fund increases in the cost of solid waste disposal as summarized above.

This issue is currently being addressed by the World Bank in the Sebou River Project. This project is evaluating waste management practices in Fez, which affect the water quality of the Sebou River. The World Bank draft report recommends that a separate tariff be established to fund the increased costs for improved solid waste management, but such a tariff must be approved by the Ministry of the Interior (MOI). World Bank officials are actively pursuing this matter with the MOI and other ministries at the national level.

Current Moroccan law is not clear on the ability of local governments to enter into long term contracts for providing municipal services. Since long term contracts will be an essential part of privatization, both the issue of increasing revenues and long term contracts must be resolved before privatization can be considered.

6.2 Privatization

Given the difficulties in financing new or improved public service programs, privatization of the new proposed landfill should be considered. The private sector can improve the delivery of service and potentially reduce costs by being more efficient managers of equipment and manpower. The private sector also has more financial resources to draw from but generally pays higher interest rates than the public sector. The increase in efficiency and cost reduction is proportional to the complexity of the service being privatized. For instance, privatization of large waste collection systems, involving large numbers of trucks, containers and manpower, has a greater potential for increasing efficiency and reducing costs than a more basic service like operating a landfill.

Landfill operation is not complex. It relies on the efficient operation of large equipment and technical efficiency of a relatively small operating staff. A key factor in evaluating the potential savings of privatization is a comparison of equipment costs to total costs. Generally, equipment costs for landfill operation are 40 to 45 percent of total costs. This compares to 30 to 35 percent for typical waste collection systems. Since the private sector generally pays a higher interest rate on capital expenses, the fixed costs for equipment purchase will be higher for the private operator. Generally, the private sector can more than offset the higher capital costs by being more efficient managers of that equipment and operating personnel.

If City officials would like to pursue privatization of the landfill operations, they should develop a privatization strategy that includes the following actions:

1. Precisely define the services to be privatized.

2. Determine total existing costs of service, including both direct and indirect costs.

3. Determine the availability, experience and interest of private firms in performing the service.

4. Evaluate the public costs for contract administration and supervision of the private contractor.

5. Develop a legal framework for protecting the City's interest as well as ensuring payment to the contractor.

6. Develop regulations regarding clandestine dumping, scavenging and other activities that may hinder private operation of the landfill.

7 RECYCLING ISSUES

Operations at the existing landfill are being hindered by the number of scavengers, grazing animals and other non-essential activities. The beginning of the new landfill offers a good opportunity to correct these problems.

Recycling and sorting of the waste to remove materials is a very positive waste management function and should be encouraged. At present, most of the materials sorting is occurring within the collection system: scavengers are sorting through materials before they are loaded onto collection trucks. Collection workers also sort and remove recyclable materials to supplement their low incomes. By the time the collected waste reaches the landfill there are few remaining materials to be sorted. The materials that do remain bring a lower price since they are dirty and contaminated by the general waste and must be cleaned before they can be sold. Unfortunately, there are still many scavengers who sort through the waste at the landfill searching for recyclable materials.

Most of the materials removed from the waste are sold to materials processors who clean, package and sell them to markets in the larger cities. These materials processors are located at places frequented by the waste collection trucks, who supply much of the materials. Therefore, there is a small community of materials processors located at the existing landfill and near several of the municipal depots within the communes. Although these establishments provide an overall positive impact on the landfill by reducing the amount of waste, their locations complicate landfill operations, impede traffic flow and lead to a general degrading of the area.

Another related problem is the grazing of animals on the landfill. During the last site visit, the ICMA consultant estimated that more than 200 cattle and sheep were grazing on the landfill. The existence of these animals prohibits proper compaction and covering of the landfill and is a serious health threat to the animals and those who may eat their meat or consume their milk. Considering the amount of medical and harmful industrial waste that is dumped at the landfill, this situation is a major health problem. This practice should be terminated prior to covering the existing landfill and should be prohibited at the new landfill.

When the new landfill begins operation, it is probable that these negative activities will reoccur at the new site. Although the eight kilometer distance from the City to the new site may discourage some of these activities, the lure of the materials could cause a settlement of materials processors and scavengers at the new site or in the villages near the site. This should be discouraged.

Fortunately, the City has a resource that could offer an alternative to the current situation. The former compost facility, located along the Tanger road, is vacant and serving no useful purpose. The large, covered maturation pads that previously contained the compost piles could be converted into a recycling center where individual materials processors could locate their operations in a more suitable and controllable environment. The Urban Community could operate the facility and charge a small fee for renting space, which could cover costs of administration. The covered space, increased storage and potential for cooperative agreements between processors would all be positive impacts for both the processors and the City. Ideally, the materials processors could eventually form a cooperative and manage the site themselves, without City involvement.

Refuse trucks going to the landfill could drop off their recyclables before making the six kilometer trip to the landfill. The same trucks could also bring materials from the landfill to the recycling center on the return trip, when they would normally be empty.

Recycling and sorting at the landfill should be strictly controlled. All scavengers should be required to register with the site manager, and all materials should be removed from the site at the end of each day. Materials processors should not be permitted to locate at the new landfill, nor should any other structures besides those needed for landfill operation.

Although the grazing of animals at the landfill should be prohibited, the separation of organic materials at the source of generation for use as animal feed should be encouraged. This activity could also be located at the former compost facility.

ATTACHMENT A

MEKNES LANDFILL SITE
HYDROGEOLOGY INVESTIGATIONS
SCOPE OF WORK

General

The City of Meknes has located a landfill site along the road to Tanger and plans to develop a sanitary landfill at that location in the near future. The general hydrogeologic setting has been identified, in a 1967 hydrogeologic map of the Meknes-Fez Plain, as deep blue clay without significant groundwater resources. Prior to proceeding with design of the site, the City requires site specific confirmation of the base soils on the site and local hydrogeologic features. This scope of work describes the field investigations, soils analysis and professional interpretations requested to meet this requirement. All work shall be performed under the supervision of a qualified hydrogeologist.

Test Borings

A minimum of four test borings shall be performed on the site at the locations indicated on the attached map. Borings shall be drilled to 2 meters below groundwater or a maximum depth of 10 meters, whichever is greater. One of the four borings shall be drilled to a depth of 20 meters. A written log of the soils encountered shall be kept of each boring and samples shall be obtained at 2 meter intervals or change in soil formation. The volume of the samples shall be adequate to perform the laboratory analyses described below.

Test Boring/Sampling Well

In the event that groundwater is encountered in any of the four borings described above, a fifth boring shall be performed at the approximate location indicated on the map with a sampling well installed according to accepted geological standards. The well screen shall extend at least 3 meters below the groundwater level.

Test Pits

In addition to the borings described above, six test pits shall be dug at the locations indicated on the map. Test pits shall be at least 3 meters in depth. A written log shall be prepared for each pit describing the soils and groundwater encountered.

Laboratory Testing

Two representative samples of soil shall be obtained from a depth of 2 meters from either borings or test pits and tested for grain size distribution, permeability in cm/sec and moisture content.

General Information

In addition to the on-site field investigation, a superficial inspection of the surrounding area within 2 kilometers shall be performed, noting any unusual surface feature or excavation that exposes geological features. This shall include the river channel located west of the landfill site.

The inspection shall include an inventory of all potable water sources or wells within 2 kilometers of the site.

Report

The results of the field testing, soils analysis and area investigations shall be summarized in a concise report. The report shall include the written logs of all borings and test pits and results of the laboratory soils analysis.

ATTACHMENT B

WASTE GENERATION DATA BASE